Slicing the Pie: Quantifying the Aggregate and Distributional Effects of Trade

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Motivation

- Gravity models $\rightarrow$ quantify *aggregate* welfare effects of trade
- Empirical research $\rightarrow$ large *distributional* effects of trade
- How large are the aggregate gains from trade and how are they distributed?
- This paper:
  - Theoretical framework for the gains from trade and their distribution
  - GE structure for the literature on the distributional effects of trade

Overview: theory

- Framework to jointly understand and quantify the aggregate and distributional effects of trade
- Building blocks:
  - Multi-sector gravity model of trade (EK, CDK, ACR)
  - Roy-Fréchet model of labor allocation across sectors (LW)
  - Various groups of ex-ante identical workers (HHJK, BMV)
- Analytical expressions for aggregate and group-level welfare effects
- Mechanisms:
  - Aggregate effects arise from inter- and intra-sectoral trade
  - Between-group distributional impact has specific-factors intuition

Application to local labor markets

- Methodology applicable to groups by age, gender, location, etc.
  - Focus on application to groups by education and, in particular, location
- GE structure for empirical literature on trade and local labor markets
  - Exercise based on data for commuting zones x skill groups in the US
  - Link to Autor, Dorn and Hanson (2013 - ADH)
- Focus on baseline version of the model
  - Model with all goods tradable across groups
  - Most parsimonious version of the model
  - Extensions do not change essential features of baseline model

Limitations of baseline model

1. No movement of labor out of tradable sectors – extension
2. No intermediate goods - extension
3. No mobility across groups - extension
4. No costs of trade across groups - can relax
5. Strong parametric assumptions - can relax
6. No implications for within-group inequality
7. No dynamics

Model

Model

- N countries, index i, j
- S sectors, index s, k
- G groups, index g

Model: Trade Side

- Each sector is modeled as in EK:
  - Continuum of goods in $[0,1]$, CES preferences with EoS σ_s
  - National CRS technologies drawn iid-Fréchet with T_{is} and $\theta_s > \sigma_s - 1$
  - Iceberg trade costs $\tau_{ijs} \geq 1$
- Preferences across sectors are Cobb-Douglas with shares β_{is}
- Expenditure shares:

$$\lambda_{ijs} = \frac{T_{is}\left(\tau_{ijs} w_{is}\right)^{-\theta_s}}{\gamma^{-\theta_s} P_{js}^{-\theta_s}}$$

where $\gamma^{-\theta_s} P_{js}^{-\theta_s} = \sum_l T_{ls}\left(\tau_{ljs} w_{ls}\right)^{-\theta_s}$

Model: Labor Side

- Exogeneous mass L_{ig} of workers of type g in country i
- A worker from g has efficiency units z in s drawn iid from a Fréchet dist. with $\kappa > 1$ and A_{igs}
- w_{is} is the wage per efficiency unit in sector s of country i
  - w_{is} same across g: national p_{iis}, T_{is}
  - w_{is} can differ across s: upward sloping labor supply to each s
- Results: share of workers in group g who choose to work in sector s is

$$\pi_{igs} = \frac{A_{igs} w_{is}^{\kappa}}{\Phi_{ig}^{\kappa}} \text{ with } \Phi_{ig} \equiv \left(\sum_{k} A_{igk} w_{ik}^{\kappa} \right)^{1/\kappa}$$

Labor Market Equilibrium

- Demand for efficiency units in sector s in country i is (cfr. EK)

$$\frac{1}{w_{is}} \sum_j \lambda_{ijs} \beta_{js} Y_j,$$

- Share of workers in group g that choose to work in sector s is (cfr. LW)

$$\pi_{igs} = \frac{A_{igs} w_{is}^{\kappa}}{\Phi_{ig}^{\kappa}} \text{ with } \Phi_{ig} \equiv \left(\sum_k A_{igk} w_{ik}^{\kappa} \right)^{1/\kappa}$$

- Equilibrium: find w_{is} that equalize demand and supply of efficiency units. ▸ Equations ▸ Graphically

- Comparative statics: "exact hat algebra" (DEK) to compute counterfactual $\hat{\lambda}_{iis}$ and $\hat{\pi}_{igs}$

Comparative Statics: Welfare

- Define $y_{ig} = \frac{Y_{ig}}{L_{ig}}$. Given all $\widehat{w}_{is}$ we can get $\widehat{\lambda}_{iis}$ and $\widehat{\pi}_{igs}$ and then

$$\widehat{y}_{ig} / \widehat{P}_i = \widehat{\Phi}_{ig} / \widehat{P}_i \text{ (from } y_{ig} = \eta \Phi_{ig} \text{)}$$

$$= \widehat{\Phi}_{ig} / \prod_s \widehat{P}_{is}^{\beta_{is}} \text{ (Cobb-Douglas preferences)}$$

$$\text{from } \lambda_{iis} = \frac{T_{is} w_{is}^{-\theta_s}}{\eta^{\theta_s} P_{is}^{-\theta_s}} \text{ and } \pi_{igs} = \frac{A_{igs} w_{is}^{\kappa}}{\Phi_{ig}^{\kappa}}:$$

$$= \underbrace{\prod_s \widehat{\lambda}_{iis}^{-\beta_{is}/\theta_s}}_{Multi-sector\ ACR} \cdot \underbrace{\prod_s \widehat{\pi}_{igs}^{-\beta_{is}/\kappa}}_{Group-level\ \text{“}Roy\text{”}\ term}$$

Empirical Analysis and Estimation of κ

Data

- For i = US, sector s
- US Labor Market:
  - Census and ACS data
  - Group employment shares at the Commuting Zone (CZ)-Skill level
  - G = 1,444 (722 CZs x 2 skill groups)
  - S = 14, with 13 manufacturing sectors and 1 non-manufacturing sector
  - Time period: 2000 - 2011
- Trade data from WIOD

The rise of China as a trade shock

- Identification as in ADH:
  - The "rise of China" is an exogenous supply shock that affects all developed economies in similar fashion.
- Import-penetration variable in the style of ADH for each $s \in M$:

$$\Delta IP_s^{China \to Other} \equiv \frac{\Delta M_s^{China \to Other}}{L_{US,s}}$$

  - $\Delta M_s^{China \to Other}$: change in imports of "Other" from "China"
  - "Other" is set of developed countries similar to US (as in ADH).
  - $L_{US,s}$ is the level of employment in the US in sector s, in 2000
- Our instrument is a Bartik (1991)-type variable:

$$\sum_{s \in M} \pi_{gs}^{M} \Delta IP_s^{China \to Other}$$

Structural estimation of κ

- From $\hat{\pi}_{igs} = \frac{\hat{A}_{igs}\hat{w}_{is}^{\kappa}}{\hat{\Phi}_{ig}^{\kappa}}$, for all sectors s:

$$\hat{y}_g = \hat{w}_s \hat{\pi}_{gs}^{-1/\kappa} \hat{A}_{gs}^{1/\kappa}$$

- Focusing on the non-manufacturing (NM) sector and taking logs:

$$\ln \hat{y}_g = \alpha - \frac{1}{\kappa} \ln \hat{\pi}_{gNM} + \varepsilon_g$$

  - Where $\alpha \equiv \ln \hat{w}_{NM}, \varepsilon_g \equiv \ln \hat{A}_{gNM}^{1/\kappa}$
  - Use the Bartik China-shock as an instrument for $\ln \hat{\pi}_{gNM}$

Table: Estimation of κ

	Dependent variable: $\ln \hat{y}_g$		
	(1)	(2)	(3)
	Workers	Hours	Earnings
$\ln \hat{\pi}_{gNM}$	-0.466	-0.494	-0.512
	(0.161)	(0.166)	(0.181)
Implied κ	2.147	2.024	1.952
	(0.743)	(0.682)	(0.689)
First-stage F-Statistic	23.19	20.43	9.902
Observations	1444	1444	1444

IV-estimation results where y_g is measured as average earnings per worker, and π_{gNM} is the labor share employed in non-manufacturing. Labor shares π_{gs} are measured as the share of workers, share of labor hours and share of earnings for columns 1, 2 and 3 respectively. Conley standard errors (in parentheses), with a cutoff for the spatial correlation at approximately 400km.

Model-based Bartik measure of import competition

- For $\kappa \to 1$, the data provides sufficient statistics for group-level gains from trade
- In this case,

$$\frac{\widehat{Y}_{ig}^{A}}{\widehat{Y}_{i}^{A}} = I_{ig} \equiv \sum_{s} \pi_{igs} \frac{\beta_{is}}{r_{is}}$$

with $r_{is} \equiv \sum_g \pi_{igs} Y_{ig} / Y_i$

- For any foreign shock, if $\kappa \to 1$

$$\ln \widehat{Y}_{ig} / \widehat{Y}_i = \ln \sum_{s} \pi_{igs} \widehat{r}_{is} = \ln \widehat{I}_{ig}$$

Taking the Bartik measure to the data

- Bartik measure of import competition:

$$\ln \widehat{Y}_{ig} / \widehat{Y}_i \approx \ln \sum_s \pi_{igs} \widehat{r}_{is}$$

  - This relationship is exact for $\kappa \to 1$, and almost exact for $\kappa > 1$
    Simulation results

- Test empirical relationship for the China shock:

$$\ln \hat{y}_g = \alpha + \beta \ln \sum_s \pi_{gs} \hat{r}_s + \varepsilon_g$$

  - Use the Bartik China-shock as an instrument for $\ln \sum_s \pi_{gs} \hat{r}_s$

- Using counterfactual simulations, we can examine the relationship between κ and β: Simulation results
- We find $\beta \approx 1/\kappa$, so our estimates imply a value of κ around 1.5

(a) First Stage: $\ln \sum_s \pi_{gs} \hat{r}_s = \alpha + \beta \sum_{s \in M} \pi_{gs}^M \Delta IP_{st}^{China \to Other} + \varepsilon_g$

	(1) Workers	(2) Hours	(3) Earnings
$\sum_{s \in M} \pi_{gs}^M \Delta IP_{st}^{China \to Other}$	-0.00348	-0.00779	-0.00151
	(0.000982)	(0.00218)	(0.000505)
F Statistic	12.52	12.71	8.924

(b) Second Stage: $\ln \hat{y}_g = \alpha + \beta \ln \sum_s \pi_{gs} \hat{r}_s + \varepsilon_g$

	(1)	(2)	(3)
$\ln \sum_s \pi_{gs} \hat{r}_s$	0.712	0.703	0.648
	(0.228)	(0.221)	(0.212)
Observations	1444	1444	1444

y_g is measured as average earnings per worker and the π_{gs} are measured as the share of workers, share of labor hours and share of earnings for columns 1, 2 and 3 respectively. Conley SEs (in parentheses) have a cutoff for the spatial correlation at ca. 400km.

Counterfactual Analysis

Overview of counterfactuals

- Throughout, $\theta_s = 5$, as in Head & Mayer (2014)
- Return to autarky for the United States: Autarky Results
  - Gains from trade are 1.52%, with coefficient of variation of 33%.
  - Some groups lose substantially from free trade, and trade increases inequality.
- Next: the "rise of China"

China-shock calibration

- Calibration of $\widehat{T}_{China,s}$
  - Inspired by Caliendo, Dvorkin & Parro (2016)
- Run a variation on ADH's first-stage regression for our data

$$\hat{\lambda}_{China,US,s} = \alpha + \beta \hat{\lambda}_{China,Other,s} + \varepsilon_s$$

  - Obtain $\widehat{\hat{\lambda}_{China,US,s}} \equiv \hat{\beta} \hat{\lambda}_{China,Other,s}$
  - Calibrate $\widehat{T}_{China,s}$ to fit the simulated $\hat{\lambda}_{China,US,s}$ to $\widehat{\hat{\lambda}_{China,US,s}}$

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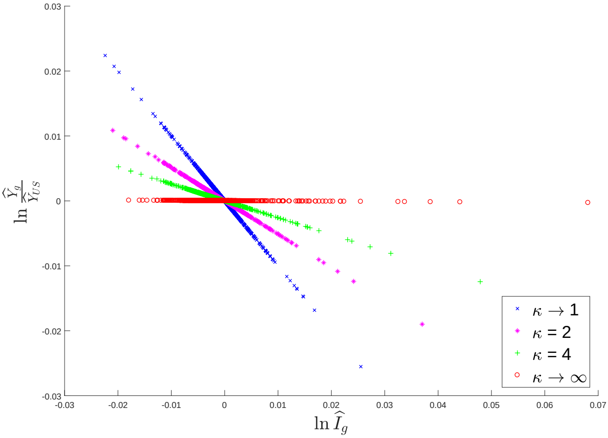
Simulated China shock and groups' income changes

κ	$\widehat{W}_{US}$	Mean	CV	Min.	Max.	$\prod_s \widehat{\lambda}_s^{-\beta_s/\theta_s}$
$\to 1$	0.29	0.38	0.87	-2.24	2.56	0.20
2	0.25	0.32	0.56	-1.64	1.34	0.20
4	0.23	0.28	0.36	-1.01	0.76	0.21
$\to \infty$	0.24	0.24	0.00	0.24	0.24	0.24

The first column displays the aggregate welfare effect of the China shock for the US, in percentage terms $(100(\widehat{W}_{US} - 1))$, and the second column shows the mean welfare effect: $100(\frac{1}{G}\sum_g \widehat{W}_{US,g} - 1)$. The third column shows the coefficient of variation (CV), and for the fourth and fifth column we have Min.$\equiv \min_g 100(\widehat{W}_{US,g} - 1)$ and Max.$\equiv \max_g 100(\widehat{W}_{US,g} - 1)$, respectively. The final column displays $100\left(\prod_s \widehat{\lambda}_{US,US,s}^{-\beta_{US,s}/\theta_s} - 1\right)$. The values for $\hat{T}_{China,s}$ are calibrated for $\kappa = 2$. Back

China simulations: Bartik measure of import competition



- For $\kappa \to 1$, $\widehat{Y}_{ig} / \widehat{Y}_i = \sum_s \pi_{igs} \widehat{r}_{is}$. Linear relation persists for $\kappa > 1$. Back

Theory: Inequality-Adjusted Welfare Effects

- Let $W_{ig} \equiv Y_{ig} / P_i$. Utility for agent behind the veil of ignorance

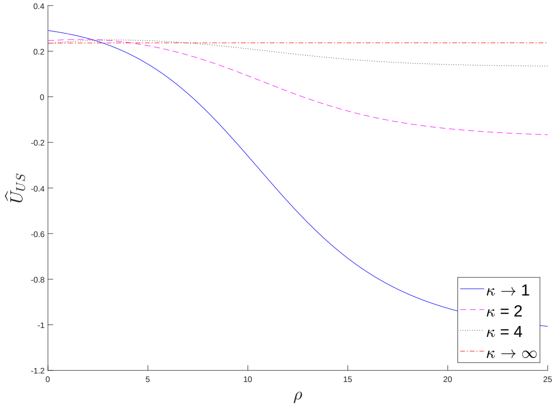
$$U_i \equiv \left(\sum_g \frac{L_{ig}}{L_i} W_{ig}^{1-\rho} \right)^{1/(1-\rho)}$$

- The higher ρ, the more risk (or inequality) averse
  - For $\rho = 0$, $U_i = W_i$, with $W_i \equiv \sum_g \frac{L_{ig}}{L_i} W_{ig}$

- Inequality-adjusted welfare effects:

$$\widehat{U}_i$$

Inequality-adjusted welfare effects



The figure plots the relationship between $\hat{U}_i$, the inequality-adjusted welfare effects of the rise of China, with $U_i \equiv \left(\sum_g l_{ig} W_{ig}^{1-\rho}\right)^{1/(1-\rho)}$, and ρ which is the coefficient of relative risk aversion for the agent behind the veil of ignorance.

Conclusion

- Framework to jointly examine aggregate and distributional effects of trade
- The welfare effects are summarized in a parsimonious equation that nests the multi-sector ACR result
- In the data, we find:
  - An estimate of κ around 2
  - Which we validate with an indirect estimation of κ using our Bartik measure of import competition
- In the simulated model, we find:
  - that the China shock increases average welfare, but some groups experience losses as high as five times the average gain
  - Adjusted for plausible measures of inequality aversion, gains in social welfare are positive, and only slightly lower than with the standard aggregation.

Equilibrium

- Excess demand for efficiency units in sector s of country i is

$$ELD_{is} \equiv \frac{1}{w_{is}} \sum_{j} \lambda_{ijs} \beta_{js} Y_j - \sum_{g} E_{igs}$$

- λ_{ijs}, Y_j and E_{igs} are functions of the whole matrix of wages $\boldsymbol{w} \equiv \{w_{is}\}$, so system $ELD_{is} = 0$ for all i, s determines all wages $\boldsymbol{w}$

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Comparative Statics: Wages

- Foreign shock: $\widehat{T}_{is}$, $\widehat{\tau}_{ijs} \neq 1$ for $i \neq j$ ($\widehat{x} \equiv x'/x$)
- Using $ELD_{is} = 0$, we can write $ELD'_{is} = 0$ as

$$\sum_g \widehat{\pi}_{igs} \widehat{\Phi}_{ig} \pi_{igs} Y_{ig} = \sum_j \widehat{\lambda}_{ijs} \lambda_{ijs} \beta_{js} \sum_g \widehat{\Phi}_{jg} Y_{jg}$$

with

$$\widehat{\Phi}_{ig} = \left(\sum_k \pi_{igk} \widehat{w}_{ik}^{\kappa} \right)^{1/\kappa},$$

$$\widehat{\lambda}_{ijs} = \frac{\widehat{T}_{is} \left(\widehat{\tau}_{ijs} \widehat{w}_{is} \right)^{-\theta_s}}{\sum_k \lambda_{kjs} \widehat{T}_{ks} \left(\widehat{\tau}_{kjs} \widehat{w}_{ks} \right)^{-\theta_s}},$$

$$\hat{\pi}_{igs} = \frac{\widehat{w}_{is}^{\kappa}}{\sum_k \pi_{igk} \widehat{w}_{ik}^{\kappa}}$$

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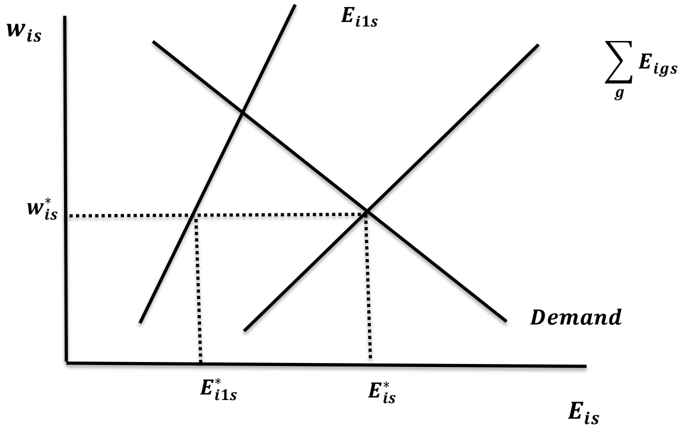
Supply and Demand of E_{is}



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First-stage estimation results

Table: Dependent variable: $\ln \hat{\pi}_{gNM}$

	(1) Workers	(2) Hours	(3) Earnings
$\ln \sum_{s \in M} \pi_{gs}^{M} \Delta IP_{st}^{China \to Other}$	0.000330	0.000323	0.000296
	(0.0000358)	(0.0000366)	(0.0000485)
P-value	2.76e-20	1.01e-18	1.05e-09
Observations	1444	1444	1444

π_{gNM} is the labor share employed in non-manufacturing. Labor shares π_{gs} are measured as the share of workers, share of labor hours and share of earnings for columns 1, 2 and 3 respectively. Conley standard errors (in parentheses), with a cutoff for the spatial correlation at 500km.

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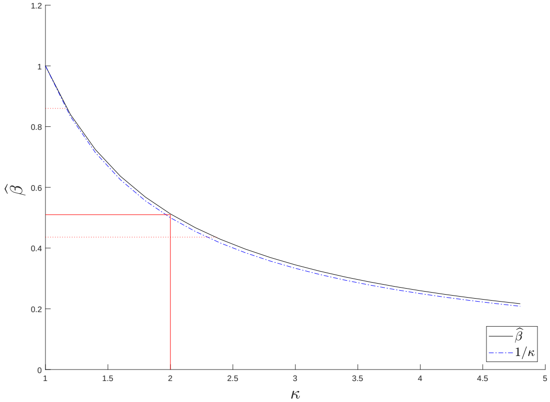
Bartik measure: regressions on simulated data



We regress $\ln \hat{y}_g = \alpha + \beta \ln \sum_s \pi_{gs} \hat{r}_s + \varepsilon_g$ on simulated data and display the obtained β for data generated for a given κ. Back

The United States move to autarky

κ	$\widehat{W}_{US}$	Mean	CV	Min.	Max.	$\prod_s \widehat{\lambda}_s^{-\beta_s/\theta_s}$
$\to 1$	1.60	1.80	0.59	-7.86	3.36	1.45
2	1.52	1.63	0.33	-3.19	2.41	1.45
4	1.48	1.54	0.18	-0.87	1.93	1.45
$\to \infty$	1.45	1.45	0.00	1.45	1.45	1.45

The first column displays the aggregate gains from trade for the US, in percentage terms $(100(1-\widehat{W}_{US}))$ and the second column shows the mean welfare effect: $100(\frac{1}{G}\sum_g 1-\widehat{W}_{US,g})$. Here, $\widehat{W}_{US}$ and $\widehat{W}_{US,g}$ are the aggregate and group-level welfare change from a return to autarky for the US. The third column shows the coefficient of variation (CV), and for the fourth and fifth column we have Min.$=\min_g 100(1-\widehat{W}_{US,g})$ and Max.$=\max_g 100(1-\widehat{W}_{US,g})$, respectively. The final column displays $100\left(1-\prod_s \widehat{\lambda}_{US,US,s}^{-\beta_{US,s}/\theta_s}\right)$.

Back to Overview